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Abstract

Low voltage electrical stimulation (ES) during bleeding and subsequent carcass chilling at 36 to 46° F resulted in 1) a more rapid pH decline 2) initial lighter red color, but more rapid discoloration during display 3) softer and coarser textured lean 4) reduced water holding capacity and juiciness and 5) decreased tenderness of the loin eye longissimus (LE) muscle when compared to the non-stimulated control (C) LE muscle. ES effects on top round semimembranosus (TR) muscle were limited to a more rapid pH decline and lower water holding capacity. Our results indicate that ES soon after slaughter, coupled with relatively slow initial chilling may reduce meat quality. More rapid initial chilling of C and ES carcasses and/or delaying the ES application may be necessary for ES to express its frequently observed desirable results.

Keywords

Cattlemen's Day, 1984; Kansas Agricultural Experiment Station contribution; no. 84-300-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 448; Beef; Electrical stimulation; Loin eye; Top Round

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Effects of Low Voltage Electrical Stimulation During Bleeding on Characteristics of Beef Loin Eye Top Round Muscles

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Summary

Low voltage electrical stimulation (ES) during bleeding and subsequent carcass chilling at 36 to 46° F resulted in 1) a more rapid pH decline 2) initial lighter red color, but more rapid discoloration during display 3) softer and coarser textured lean 4) reduced water holding capacity and juiciness and 5) decreased tenderness of the loin eye longissimus (LE) muscle when compared to the non-stimulated control (C) LE muscle. ES effects on top round semimembranosus (TR) muscle were limited to a more rapid pH decline and lower water holding capacity.

Our results indicate that ES soon after slaughter, coupled with relatively slow initial chilling may reduce meat quality. More rapid initial chilling of C and ES carcasses and/or delaying the ES application may be necessary for ES to express its frequently observed desirable results.

Introduction

Electrical stimulation (ES) accelerates post-mortem pH decline (measure of acidity), improves tenderness, reduces the incidence of heat ring formation, improves marbling scores and produces a brighter, more youthful colored longissimus muscle (loin eye). By decreasing the time between bleeding and stimulation, pH decline may be faster and rigor mortis onset (beginning of carcass stiffening) may be sooner, making it more feasible for commercial operations to cut carcasses before chilling (hot boning). However, with a very rapid pH decline, muscle may become pale in color and have a reduced water holding capacity. Therefore, we minimized the time by stimulating during bleeding and observed the effects on meat quality characteristics.

Experimental Procedures

Forty steers were allotted by feeding regimen (accelerated and conventional) and breed (Hereford and Simmental) to four slaughter groups. Five steers from each slaughter group were assigned randomly to low voltage electrical stimulation (ES) during bleeding (approximately 5 min after stunning) and five were assigned as non-stimulated controls (C). ES consisted of approximately 50 volts of 60 Hz pulsating (1 sec on and 1 sec off for 2 min) current. After slaughter, carcasses were chilled at 36 to 46° F and ribbed and graded at 28 hr post-mortem. Temperature and pH measurements were recorded at 1, 2, 4, 6, 8 and 24 hr post-mortem.

At 48 hr post-mortem, the loin eye longissimus (LE) and top round semimembranosus (TR) muscles were removed, vacuum packaged and aged for 4 days. LE and TR steaks then were cut for taste panel, Warner-Bratzler shear force (WBS), display color and water holding capacity (WHC) evaluation. Taste panel and WBS steaks were frozen and stored at -4° F until evaluated. Color steaks were packaged in polyvinylchloride film and evaluated at 0, 1, 3 and 5 days of lighted (100 foot candles) display (37° F). WHC steaks were stored at 35 to 39° F for 2 days. Then triplicate (approximately 0.5 g) meat cores on individual sheets of humidified Whatman No. 1 filter paper were placed between two plexiglas plates and pressed for 1 min at 500 psi (lbs per in^2) using a Carver Laboratory Press.

Results and Discussion

Temperature of the LE and TR muscles of ES carcasses were similar to C counterparts ($P>.05$) at 2, 4, 6, 8 and 24 hr after death. At 24 hr the LE and TR temperatures were 52 and 56° F, respectively, for both ES and C. LE pH values were lower ($P<.05$) for ES through 6 hr, but similar ($P>.05$) at 24 hr (Table 2.1). TR pH values were lower ($P<.05$) for ES than C from 1 to 8 hr, but were similar ($P>.05$) at 24 hr (Table 2.1).

When observed at 28 hr post-mortem, ES LE was lighter in color, softer, coarser in texture ($P<.05$) and had less marbling ($P=.08$) than C (Table 2.2). Several ES LE muscles had a two-toned color appearance.

ES LE steaks were lighter red at 0 and 1 day and more discolored at 5 days of display than C steaks ($P<.05$, Table 2.3). ES TR muscles were lighter red ($P<.05$) at 0 day but similar ($P>.05$) to C at 3 and 5 days of display. Within the TR, the deep portion adjacent to the adductor was lighter red at 0 day but more discolored at 3 and 5 days of display, and had less water holding capacity than the superficial TR ($P<.05$). ES LE and TR samples had less ($P<.05$ and $P=.08$, respectively) water holding capacity than C (Table 2.3).

A trained taste panel found that ES LD was less juicy and had more myofibrillar and overall toughness than C ($P<.05$, Table 2.4). ES LE also tended ($P=.13$) to have greater Warner-Bratzler shear force values than C. ES LE had increased cooking loss ($P<.05$) compared with C in two of the four slaughter groups. SM shear force, cooking loss and taste panel evaluations were similar ($P>.05$) between ES and C (Table 2.4).

Even though numerous researchers have shown that ES is benefical, our results indicate that ES soon after slaughter coupled with relatively slow initial chilling (36 to 46° F) may produce undesirable results. ES resulted in decreased WHC, tenderness and color stability. Therefore, caution should be observed when using conditions similar to those in our study. More rapid initial chilling of C and ES carcass than that used in this study and/or delaying the ES application may be necessary for ES to express its frequently observed desirable results.

Table 2.1. Means for pH of the Loin Eye (LE) and Top Round (TR) Muscles by ES[a] and Control (C) Treatments

Hours postmortem	LE		TR	
	ES	C	ES	C
1	5.9[b]	6.8[c]	6.0[b]	6.8[c]
2	5.6[b]	6.4[c]	5.7[b]	6.5[c]
4	5.5[b]	6.1[c]	5.6[b]	6.3[c]
6	5.5[b]	5.8[c]	5.5[b]	6.0[c]
8	5.5[d]	5.7[d]	5.5[b]	5.9[c]
24	5.6	5.6	5.6	5.6

[a]Low voltage electrical stimulation during bleeding

[bc]Means in the same row for the same muscle bearing different superscripts are different (P<.05)

[d]Treatment x slaughter group interaction resulted from ES in 3 of 4 slaughter groups having lower (P<.05) pH values than C.

Table 2.2. Twenty-eight Hour Post-mortem Carcass Characteristics by ES[a] and Control (C) Treatments

Carcass characteristics	ES	C
Marbling score	Slight[54c]	Slight[71d]
Lean color[b]	2.2[e]	2.9[f]
Lean firmness[b]	3.9[e]	2.5[f]
Lean texture[b]	4.0[e]	3.0[f]

[a]Low voltage electrical stimulation during bleeding

[b]Scores: 7 = very dark cherry red, extremely soft or very coarse texture; 4 = slightly dark cherry red, slightly soft or slightly fine texture; 3 = cherry red, moderately firm or moderately fine texture; 2 = light cherry red, firm or fine texture

[cd]Means in the same row bearing different superscripts are different (P=.08).

[ef]Means in the same row bearing different superscripts are different (P<.05).

Table 2.3. Display Color and Water Holding Capacity (WHC) of Loin Eye (LE) and Top Round (TR) Muscles by ES[a] and Control (C) Treatments

Days of display[b]	LE		TR	
	ES	C	ES	C
0	1.3[d]	1.9[e]	1.3[d]	1.6[e]
1	1.6[d]	2.1[e]	2.0	2.2
3	2.4[d]	2.5[e]	3.1	3.0
5	3.3[d]	3.0[e]	3.6[f]	3.5
WHC[c]	3.11[d]	2.69[e]	3.54[f]	3.34[g]

[a]Low voltage electrical stimulation during bleeding

[b]Scores: 1 = very bright red, 2 = bright red, 3= slightly dark red or brown, 4 = dark red or brown and 5 = extremely dark red or brown

[c]Moisture area divided by meat sample area.

[de]Means in the same row for the same muscle bearing different superscripts are significantly different (P<.05).

[fg]Means in the same row for the same muscle bearing different superscripts are different (P=.08).

Table 2.4. Taste Panel Evaluation, Shear Force, and Cooking Loss Means for the Loin Eye (LE) and Top Round (TR) Muscles by ES[a] and Control (C) Treatments

Variable	LE		TR	
	ES	C	ES	C
Flavor intensity[b]	6.0[c]	6.3[d]	6.1	6.2
Juiciness[b]	5.8[c]	6.1[d]	5.8	5.7
Myofibrillar tenderness[b]	5.8[c]	6.4[d]	5.6	5.6
Connective tissue amount[b]	6.6	6.8	5.0	4.8
Overall tenderness[b]	6.0[c]	6.5[d]	5.2	5.1
Warner-Bratzler shear force (lbs)	7.0	6.1	11.8	12.4
Cooking loss (%)	24.9[e]	21.5[e]	32.6	31.2

[a]Low voltage electrical stimulation during bleeding

[b]Scores: 7 = very intense flavor, very juicy, practically no connective tissue or very tender; 6 = moderately intense flavor, moderately juicy, trace amount of connective tissue or moderately tender; 5 = slightly intense flavor, slightly juicy, slight amount of connective tissue or slightly tender.

[cd]Means in the same row for the same muscle bearing different superscripts are different (P<.05).

[e]Treatment x slaughter group interaction resulted from ES having increased cooking loss (P<.05) in 2 of 4 slaughter groups.